

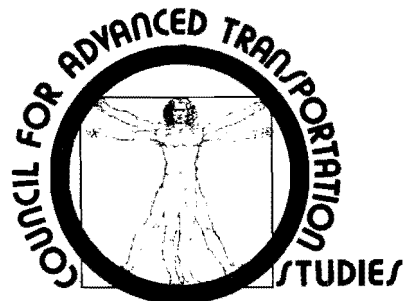
# **ALCOHOL AND ACCIDENTS**

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## **RESEARCH REPORT 49**

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ALCOHOL AND ACCIDENTS

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Austin, Texas 78712

For

Texas Office of Traffic Safety  
State Department of Highways and Public Transportation  
Austin, Texas

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16. Abstract  <p>The relationship between drinking and driving is a complex one. In general, the probability of a crash increases as blood alcohol concentration (BAC) increases. Physiological changes with increased BAC impair attention span, alertness, visual acuity, and reaction times. Risk-taking behavior is increased with alcohol consumption. Alcohol is particularly detrimental for the inexperienced driver as well as for the driver in unfamiliar territory. This report covers research of three major types: research on the physiological effects of alcohol, laboratory and simulation studies of alcohol as it affects driver skills, and epidemiological studies of alcohol-related accidents in field settings.</p>					
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## EXECUTIVE SUMMARY

The present paper is one of a series being prepared under the auspices of the Texas Office of Traffic Safety. It presents a review of relevant studies dealing with the effects of alcohol on the human body and the resultant effects on the operation of a motor vehicle.

Of the more than 50 thousand traffic fatalities recorded every year, estimates of the number attributable to alcohol range from a low of about 25 percent<sup>1</sup> to a high of more than 80 percent. Regardless of the exact percentage attributable to alcohol, it can be said that alcohol represents a significant variable.

The major physiological effects of alcohol are well documented. The reticular activation system, that part of the nervous system most sensitive to alcohol, is affected by relatively low levels of alcohol<sup>2</sup> and is affected before the cortex. Alcohol affects those types of behavior controlled by the reticular activation system, such as attention, emotion, wakefulness, and sleep.<sup>3</sup>

There have been studies that indicate that alcohol has a biphasic effect, wherein low concentrations of alcohol actually improve performance. This effect has been attributed to the depressing of some inhibitory mechanism,<sup>4</sup> to a decreasing of the excitation threshold,<sup>5</sup> and to increased motivation during the driving task or experiment. Future laboratory studies should seek to control for the possibility of increased motivation.

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<sup>1</sup>S. D. Bacon, "Traffic Accidents Involving Alcohol in the U.S.A.: Second Stage Aspects of a Social Problem," Quarterly Journal of Studies on Alcohol, Supplement No. 4 (May 1968), pp. 11-33.

<sup>2</sup>H. Kalant, "Effects of Ethanol on the Nervous System," in International Encyclopedia of Pharmacology and Therapeutics, 1, Section 20 (1970).

<sup>3</sup>M. W. Perrine, "Alcohol Influences on Driving-Related Behavior: A Critical Review of Laboratory Studies of Neurophysiological, Neuromuscular, and Sensory Activity," Journal of Safety Research, 5, No. 3 (1973), pp. 165-184.

<sup>4</sup>Ibid.

<sup>5</sup>H. Wallgren and H. Barry, III, Actions of Alcohol: Biochemical, Physiological, and Psychological Aspects, 1 (New York: Elsevier Publishing, 1970).

Of the several sensory mechanisms affected by alcohol, it would seem that vision is the most critically affected.<sup>6</sup> It has been shown that static visual acuity, dynamic visual acuity, dark adaptation, and critical flicker frequency are all adversely affected by a blood alcohol concentration (BAC) of as low as .06 percent with significant impairment beginning as the BAC approaches .10 percent.

The results of reaction time experiments have been somewhat contradictory. While some experiments have shown degradation of functions/reflexes under conditions of legal intoxication,<sup>7</sup> others have shown an increase in performance,<sup>8</sup> and still others have found no change. Again, the motivational effects are complex and must be controlled before the effect of alcohol on reaction time is really understood. In attempting to identify what portion of the reaction cycle is influenced by alcohol ingestion, it has been found that certain types of tasks are unaffected, while reaction to visual cues is affected.<sup>10</sup> Learning (experience) can mitigate the effect, but the research would suggest that inexperienced drivers and drivers in unfamiliar environments are likely to be impaired by moderate levels of alcohol (.05 percent BAC).

In other experiments it has been shown that short term memory, judgment, and risk-taking are all affected by alcohol ingestion.<sup>11</sup>

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<sup>6</sup>M. W. Perrine, op. cit.

<sup>7</sup>G. H. Robinson and W. J. Peebles, "Interactions Between Alcohol, Task Difficulty, and Compatibility in a Choice-Reaction Task," Perceptual and Motor Skills, 38 (1974), pp. 459-466.

<sup>8</sup>M. Vogel, "Low Blood Alcohol Concentrations and Psychological Adjustment as Factors in Psychomotor Performance," Quarterly Journal of Studies on Alcohol, 19 (1958), pp. 573-589.

<sup>9</sup>G. A. Zirkle, et al., "Effects of Chlorpromazine and Alcohol on Coordination and Judgment," Journal of the American Medical Association, 171, No. 11 (1959), pp. 168-172.

<sup>10</sup>V. K. Tharp, Jr., "Alcohol and Driving Performance: An Information Processing Analysis," Alcohol Technical Reports, 4, No. 2 (1975), pp. 12-18.

<sup>11</sup>P. E. Fergenson and J. M. Johnson, The Effects of Low and Moderate Levels of Alcohol Intake on Three Cognitive Parameters Related to Automobile Driving, Pre-Publication Copy (Hoboken, New Jersey: Stevens Institute of Technology).

Studies involving the driving task have been accomplished using both simulators and actual driving. Among the factors studied in the former type of experiment are steering reversal rates, accelerator reversals, brake application, visual search patterns, and eye fixation. The various studies seem to indicate that with an increase in alcohol, there is an increase in macro-reversals,<sup>12</sup> or gross over-corrections, a narrowing of concentration,<sup>13</sup> and tunnel vision.<sup>14</sup> All of these behaviors lead to an impairment of driving ability.

Studies of drivers on controlled courses lend further support to the above findings. It has been shown that there is a tendency for drivers to pay greater attention to high priority tasks as the BAC increases.<sup>15</sup> As in the laboratory studies, it was found that there is an increase in the control movements necessary to control a vehicle with a BAC of .08 percent.<sup>16</sup> It has also been demonstrated that there is an increase in risk-taking with a BAC of .01 percent.<sup>17</sup>

Epidemiological studies provide some information on the characteristics of drinking drivers. Tables I and II present partial results from two<sup>18</sup> of the larger epidemiological studies of recent years. It can be seen from these

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<sup>12</sup>G. L. Martin, "The Effects of Small Doses of Alcohol on a Simulated Driving Task," Journal of Safety Research, 3, No. 1 (1971), pp. 21-27.

<sup>13</sup>W. Buikhuisen and R. W. Jongman, "Traffic Perception Under the Influence of Alcohol," Quarterly Journal of Studies on Alcohol, 33 (1972), pp. 800-806.

<sup>14</sup>S. Schroeder, J. Ewing and J. Allen, "Combined Effects of Alcohol with Methopryilene and Chlordiazepoxide on Driver Eye Movements and Errors," Journal of Safety Research, 6 (1974), pp. 89-93.

<sup>15</sup>P. Hamilton and A. Copeman, "The Effect of Alcohol and Noise on Components of a Tracking and Monitoring Task," British Journal of Psychology, 61 (1970), pp. 149-156.

<sup>16</sup>M. S. Huntley, Jr. and T. Centybear, "Alcohol, Sleep Deprivation, and Driving Speed Effects Upon Control Use During Driving," Human Factors, 16, No. 1 (1974), pp. 19-28.

<sup>17</sup>H. T. Zwahlen, "The Effect of Alcohol on Driving Skills and Reaction Times," Journal of Occupational Accidents, 1976 (in press).

<sup>18</sup>W. L. Carlson, et al., Washtenaw County BAC Roadside Survey Report, (Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, 1971); R. L. Borkenstein, et al., The Role of the Drinking Driver in Traffic Accidents, (Bloomington, Indiana: Department of Police Administration, Indiana University, Feb. 1964).



studies that there are definite sexual and marital differences in drinking drivers. The results further suggest that some drinking drivers attempt to avoid accidents and arrest by travelling on roads with a lower traffic volume.

There seems to be no doubt that alcohol consumption seriously affects safe driving practices despite the drinking driver's attempt to compensate for her/his impairment. The effect of alcohol on traffic safety has unfortunate consequences for the drinking driver and also the nondrinker on the roads and highways.

TABLE I  
CHARACTERISTICS OF DRIVERS INTERVIEWED  
WASHTENAW COUNTY

	<u>BAC &gt; .05</u>
<u>TIME</u>	
After Midnight	21%
10 - 12 p.m.	6%
7 - 9 p.m.	5%
<u>ROAD (After Midnight)</u>	
Medium Volume	27%
High Volume	15%
<u>SEX</u>	
Male	12%
Female	4%
<u>AGE</u>	
21 - 25	28%
31 - 35	10%
51 - 55	5%
	<u>BAC &gt; .10</u>
<u>MARITAL STATUS</u>	
Divorced and Separated	11%
Married	5%
Single	2%

SOURCE: W. L. Carlson, et al., Washtenaw County BAC Roadside Survey Report, (Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, 1971).

TABLE II

CHARACTERISTICS OF DRIVERS INTERVIEWED

GRAND RAPIDS

	<u>BAC &gt; .05</u>
<u>TIME</u>	
Midnight - 3 a.m.	17.0%
9 - 12 p.m.	5.1%

SOURCE: R. L. Borkenstein, et al., The Role of the Drinking Driver in Traffic Accidents, (Bloomington, Indiana: Department of Police Administration, Indiana University, Feb. 1964).

## PREFACE

This is the first in a series of research reports describing activities and findings on accident research as part of the work conducted by the Council for Advanced Transportation Studies at The University of Texas at Austin under the auspices of the Texas Office of Traffic Safety, State Department of Highways and Public Transportation.

This report is concerned with the effects of alcohol on the human body and the resultant effects on the operation of a motor vehicle.

## ACKNOWLEDGEMENTS

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## I. INTRODUCTION

More than fifty thousand traffic fatalities are recorded in the United States each year. The sheer magnitude of this number is perhaps better understood when it is recalled that this is comparable to the total number of combat deaths recorded in either the Korean or Viet Nam conflicts. Clearly, this is a problem of "epidemic" proportions, one in which the costs include millions of dollars in damage and lost production as well as incalculable misery for family, friends and business associates who were dependent on the individual who died in an auto accident. Clearly, too, this is a problem in great need of a solution. Just what the appropriate solution or solutions might be depends in great part upon just what the underlying causes of the problem might be. If the problem is the result of a single set of variables then one type of solution might be called for; but, if this problem is the result of a different set of variables then clearly a different type of solution would be needed. It is the objective of this paper to delimit the influence of one variable -- alcohol involvement -- upon traffic safety.

The effect of alcohol consumption is one of the first things that comes to mind when the question is posed as to which variables are related to traffic accidents and fatalities. Slogans such as, "If you drink, don't drive and if you drive, don't drink," are legion and underline the general feelings about the relationship existing between alcohol consumption and traffic safety. In spite of such slogans, persons who ingest beverage alcohol probably will not change their usual mode of travel when they have been drinking unless strong, consistent, legal and social sanctions are used to intervene.

It is commonly said that about half of all traffic fatalities in the United States are alcohol related. For example, Time Magazine stated that "at least half of each year's fifty-five thousand automobile deaths and half of the one million major injuries suffered in auto accidents can be traced directly to a driver or pedestrian under the influence."<sup>1</sup> A widely-used high

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<sup>1</sup>"Alcoholism: New Victims, New Treatment." Time Magazine. April 22, 1974.

school textbook<sup>2</sup> says much the same thing, i.e., that alcohol is involved in more than half of all traffic deaths each year, although only four to five percent of the drivers on the road are legally drunk. Although the estimate of the proportion of traffic deaths varies widely -- from estimates as low as 25 percent<sup>3</sup> to estimates as high as 80 or 90 percent -- it is obvious that alcohol involvement in traffic accidents and fatalities is an extremely important variable. In fact, it is generally felt that alcohol involvement in traffic fatalities is the single most important variable in the area of traffic fatalities. However, the type of solution adopted to combat this problem necessarily depends upon an accurate determination of the extent of alcoholic involvement in traffic safety. That is, if a campaign of heroic proportions is waged against the drunk driver and if only 25 percent of all traffic fatalities are alcohol related, then we are ignoring the causes of the 75 percent of the fatalities which are not alcohol related. And, it would follow that, if the degree of alcohol-related fatalities is overestimated, then programs designed to reduce the number of drinking drivers, e.g., DWI reeducation, would have little impact upon the accident rate.

The purpose of this report is to review the literature relevant to the area of alcohol and traffic safety. To this end, the effects of alcohol upon physiological mechanisms in the body are first discussed. Next, the research evaluating the effects of alcohol upon behavior in a controlled setting such as the laboratory is reported. After this, field studies are presented in which those relatively rare events -- traffic fatalities -- are investigated.

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<sup>2</sup>M. Halsey, R. Kaywood and R. A. Meyerhoff, Let's Drive Right, 5th Ed., (Glenview, Illinois: Scott Foresman, and Company, 1972).

<sup>3</sup>S. D. Bacon, "Traffic Accidents Involving Alcohol in the U.S.A.: Second Stage Aspects of a Social Problem," Quarterly Journal of Studies on Alcohol, Supplement No. 4 (May 1968), pp. 11-33.



## II. PHYSIOLOGICAL EFFECTS OF ALCOHOL INGESTION

### GENERAL EFFECTS

The major physiological effects of alcohol are well documented. Alcohol appears in the blood within a few minutes after it is ingested. The rate at which alcohol is absorbed varies, depending on the concentration of alcohol in the drink, the blood flow in the stomach, and the amount of food in the stomach. The concentration of alcohol in the blood rises rapidly during the initial period of ingestion and absorption (in about thirty minutes to two hours, the peak effect is reached and then the effect slowly declines). Furthermore, the concentration of alcohol in the blood is a relatively reliable index of that in the brain.

McFarland reports that several factors influence the concentration of alcohol in the blood and the rate of absorption:

- (1) the amount of alcohol in a drink,
- (2) the dilution of a drink,
- (3) the presence of food, which retards rate of absorption,
- (4) the fact that alcohol in brewed beverages such as beer is absorbed more slowly due to the presence of carbohydrates, and
- (5) drinking slowly, which allows time for the body to dispose of some of the alcohol.<sup>4</sup>

The blood alcohol concentration (BAC) level is a measure of the percentage of alcohol in the blood of an individual. Accident frequencies begin to increase at a level of about .04 to .06 percent blood alcohol. At a level of about .10 percent, the risk of being involved in a single vehicle crash increases by tenfold and in any accident by fivefold. With .12 to .14 percent levels, the risk increases to twenty-five times that for no alcohol consumption. Figure 1 provides a chart indicating the BAC level in an individual depending on: (a) the amount of alcohol ingested, (b) body weight, and (c) whether the stomach is full or empty. Haddon and Bradess report that among 83 fatalities resulting from single vehicle accidents over an eight-year period in Westchester County, New York, from which postmortem determinations for

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<sup>4</sup>R. A. McFarland, The Effects of Alcohol on Driving Performance, Paper presented at the 43rd Annual Maine State Safety Conference, Kennebunkport, Maine, October 1, 1970.

\*Lay a straightedge across your weight and number of ounces of liquor you've consumed on empty or full stomach. The point where the edge hits the right-hand column is your blood alcohol level. At .05 percent, many persons begin to have driving ability affected. At .10 percent, you're at an illegal level in 15 states. In 28 other states, a .15 percent level is considered presumptive guilt of drunken driving.

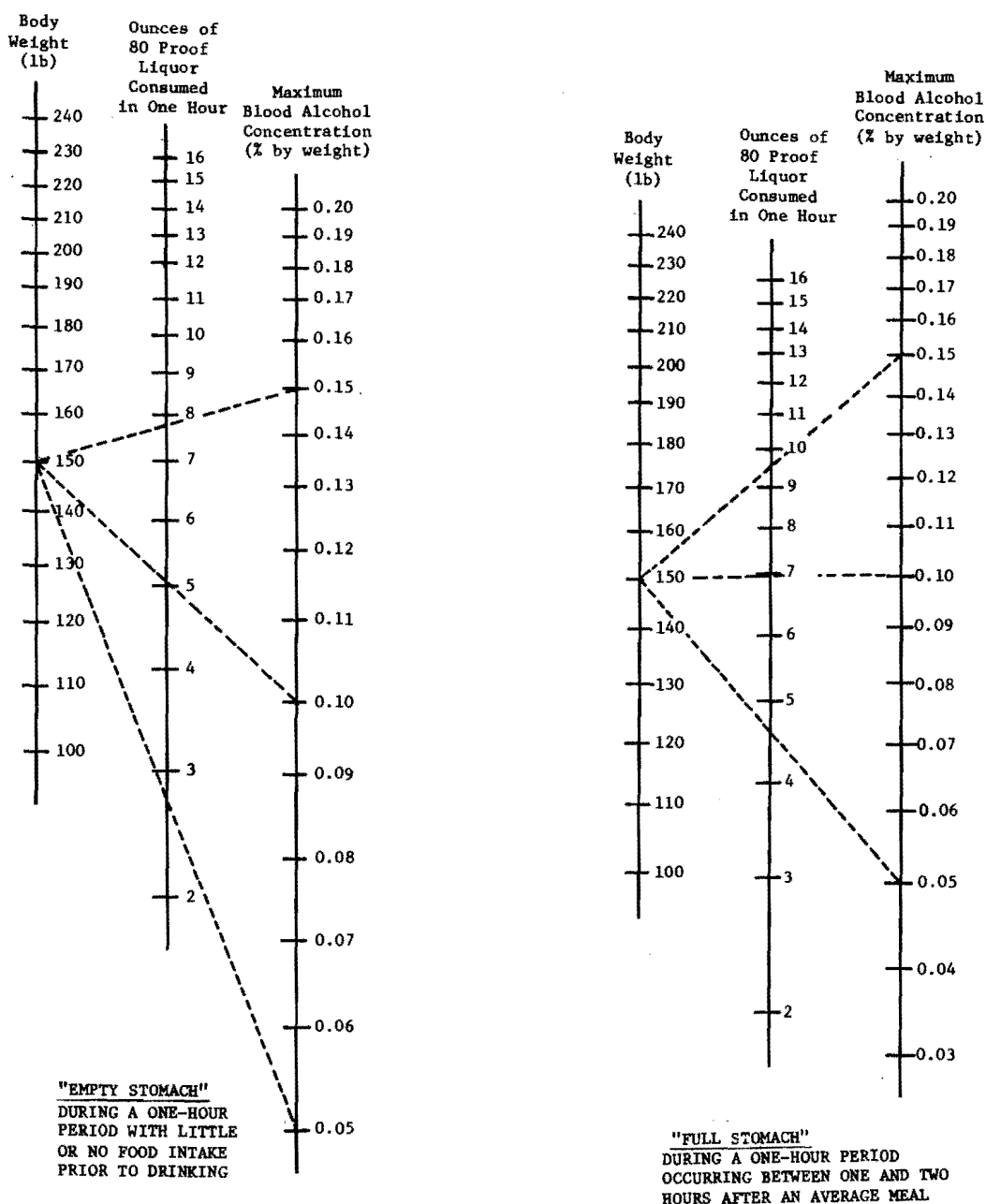


FIGURE 1  
 HOW TO TELL WHAT YOUR BLOOD ALCOHOL LEVEL IS AFTER DRINKING

FROM: R. A. McFarland, The Effect of Alcohol on Driving Performance, Paper presented at the 43rd Annual Maine State Safety Conference, Kennebunkport, Maine, October 1, 1970, Figure 1.

alcohol were conducted, 49 percent had BAC levels of .15 percent or more and an additional 20 percent had BAC levels of .05 percent to .15 percent.<sup>5</sup>

McFarland graphs the probability of a crash for various blood alcohol concentrations. Figure 2 shows that the curve becomes steeper as BAC increases.<sup>6</sup>

#### SPECIFIC EFFECTS

One approach to determining the effects of drinking on driving is to look at the effects of alcohol on various physiological mechanisms of the body. As in other situations, physiological changes may or may not be related to behavioral changes. It may be inappropriate to conclude that there was any necessary correlation between the effects of alcohol, say, upon certain neural mechanisms and the extremely complex behaviors involved in driving a car. Nevertheless, those physiological changes which occur because of alcohol ingestion may provide us with important information about what happens to the individual and what physiological changes must be compensated for in the driver's behavior.

Perrine has identified two issues in this area as being important to our understanding of the effects of alcohol upon driving performance.<sup>7</sup> The first is related to the parts of the nervous system influenced by alcohol, and the second is related to what are called "biphasic" responses to alcohol.

First, the reticular activation system is thought to be the part of the nervous system most sensitive to alcohol. The reticular activation system refers to the reticular formation -- a weblike network of fibers in the medulla -- and the interconnections this formation has with higher cortical centers.

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<sup>5</sup>W. Haddon, Jr., and V. A. Bradess, "Alcohol in the Single Vehicle Fatal Accident," Journal of the American Medical Association, 169, No. 14 (1959), pp. 127-133.

<sup>6</sup>R. A. McFarland, op. cit.

<sup>7</sup>M. W. Perrine, "Alcohol Influences on Driving-Related Behavior: A Critical Review of Laboratory Studies of Neurophysiological, Neuromuscular, and Sensory Activity," Journal of Safety Research, 5, No. 3 (1973), pp. 165-184.

\*The horizontal dotted line shows a relative probability of crash the same as that with no alcohol present in the blood. The curves for fatal crashes are believed to be considerably higher and steeper but sufficient research has not yet been done to estimate them precisely. There is also insufficient information for certainty concerning the values with blood alcohol concentrations below about 60 mg per 100 ml (0.06% by wt.).

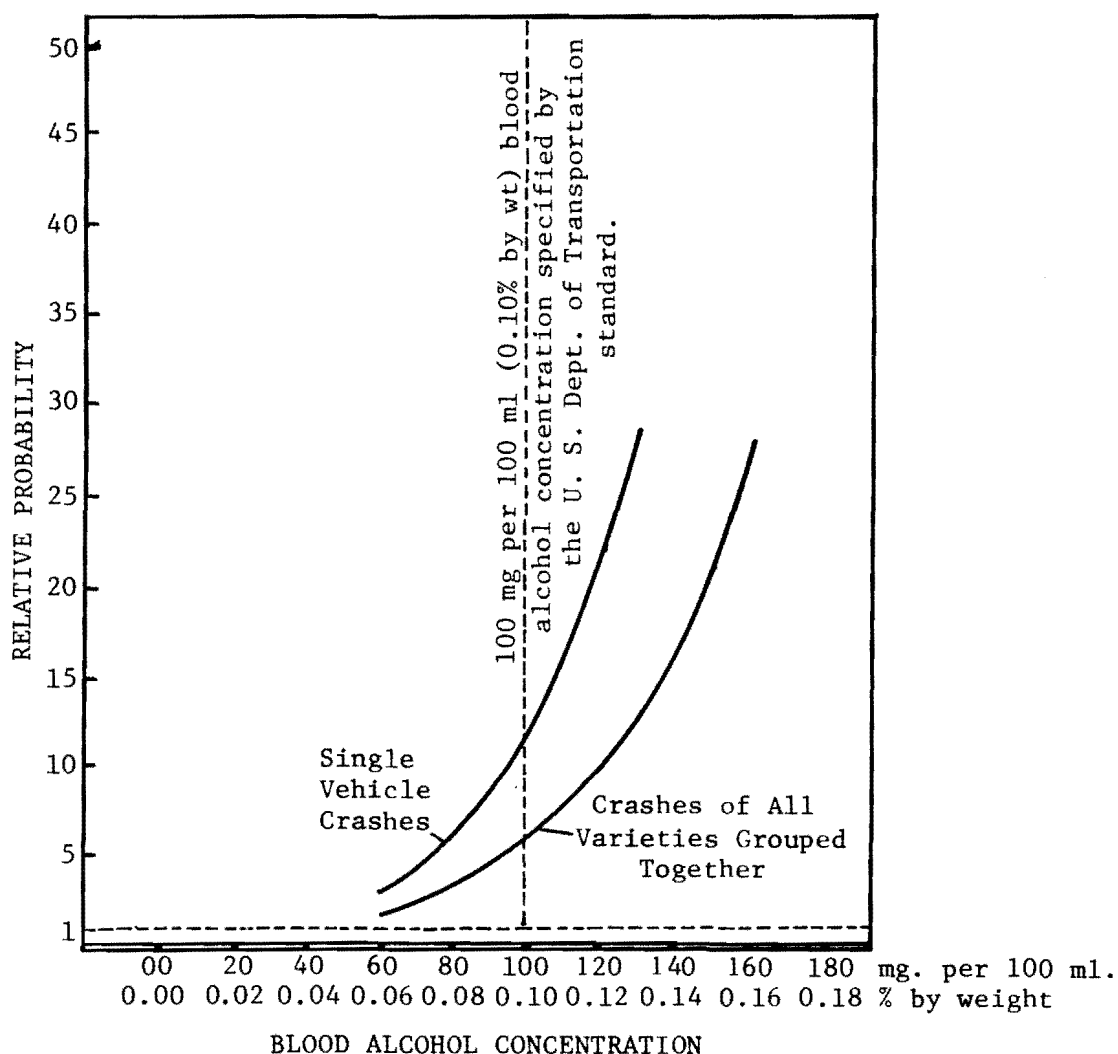


FIGURE 2

RELATIVE PROBABILITY OF CRASH AT VARIOUS BLOOD ALCOHOL CONCENTRATIONS

FROM: R. A. McFarland, The Effect of Alcohol on Driving Performance, Paper presented at the 43rd Annual Maine State Safety Conference, Kennebunkport, Maine, October 1, 1970, Figure 9.

The reticular activation system has the ability to control neural activity in the cortex and, hence, such behavioral phenomena as attention, emotion, wakefulness and sleep. In the latter case, alcohol has the effect of suppressing rapid eye movement (REM) sleep, which in turn tends to be associated with the process of dreaming.<sup>8</sup> Since REM sleep is important to rest, an alcoholic sleep is not an especially restful one. On nights when no alcohol is consumed, REM sleep is much more likely to occur, as are dreams, and the sleep appears to be more restful.

There is general agreement that the reticular activation system is influenced by relatively low levels of alcohol<sup>9</sup> and that this system is influenced sooner than the cortex. In general, there is a depression of excitability which is not necessarily found in the cortex, so that those types of behavior, such as attention, which are influenced by the reticular activation system would be expected to be depressed. In other words, the threshold for responding to a stimulus would be increased; the same stimulus would be less likely to be noticed when alcohol is present. The implications for traffic safety are obvious.

The second issue, the biphasic effects of alcohol, refers to the finding that performance under a relatively small amount of alcohol is often superior to that found with no alcohol. Wallgren and Barry relate that low concentrations of alcohol decrease the excitation threshold whereas rising concentrations change the effect to depression and finally to complete blockage.<sup>10</sup> The biphasic effect at the physiological level is explained by Perrine, who states that alcohol is consistently a neural depressant and the apparent stimulating or facilitating effects are probably due to the depressant action of alcohol on some inhibitory mechanism.<sup>11</sup> That is, if an inhibition is itself inhibited,

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<sup>8</sup>S. C. Gresham, W. B. Welsh and R. L. Williams, "Alcohol and Caffeine: Effect on Inferred Visual Dreaming," Science, 140 (1963), p. 1226.

<sup>9</sup>H. Kalant, "Effects of Ethanol on the Nervous System," in International Encyclopedia of Pharmacology and Therapeutics, 1, Section 20 (1970).

<sup>10</sup>H. Wallgren and H. Barry, III, Actions of Alcohol: Biochemical, Physiological, and Psychological Aspects, 1 (New York: Elsevier Publishing, 1970).

<sup>11</sup>M. W. Perrine, op. cit.

performance should increase. Although the phenomenon seems to be a reliable one on the physiological level, the similar effect seen at an expanded or behavioral level may be a consequence of more prosaic variables. For example, subjects serving in an experiment in which they drink relatively small amounts of alcohol may more than compensate for the effects of alcohol by increased motivation. One implication of this is that any control, or no alcohol, condition should be a placebo condition in which subjects are made to believe they are ingesting some quantity of alcohol.

The effect of alcohol appears to be greatest on the central nervous system. That is, by comparison the effects of alcohol on peripheral nerves and the muscles are slight<sup>12</sup> and the behavioral tests for estimating the amount of alcohol consumed -- walking a line, touching both index fingers, etc. -- are successful not because the muscle groups involved have been disturbed or disrupted but because the central nervous system, most likely the reticular activation system, has been affected by alcohol involvement.

It would seem that the most important sensory apparatus involved in the operation of a motor vehicle is that of vision. Consequently, whether or not there is disruption of visual perception, by ingestion of alcohol for instance, would be a most important consideration in the successful operation of a car or truck. Perrine reviewed the effects of alcohol on vision and reported a number of results.<sup>13</sup> First, static visual acuity as measured by the ability to distinguish between open and closed circles does not seem to be measureably impaired until blood alcohol concentrations (BAC) of around .08 percent have been reached. (A BAC level of .10 percent is usually the legal definition of intoxication.) Similarly, great individual differences were observed in the effects of alcohol on dynamic visual acuity. This type of acuity is essentially determined by measuring static visual acuity with moving objects. In this case, all subjects were impaired when BAC levels reached .10 percent -- the usual legal definition of intoxication. The third variable reported is that of dark adaptation -- the ability of the visual system to adjust and to respond to relatively small amounts of light. Although earlier studies seemed to support a biphasic interpretation of dark adaptation, more recent studies

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<sup>12</sup>H. Wallgren and H. Barry, III, op. cit.

<sup>13</sup>M. W. Perrine, op. cit.

have been unable to replicate such a phenomenon.<sup>14</sup> Instead, impairment of dark adaptation begins to occur at BAC levels only slightly less than the .10 percent legal definition of intoxication.

Critical flicker frequency (CFF) refers to the rate at which a blinking light is seen by the subject to stop blinking and become a continuous light source. This variable is a commonly used one in perception experiments and measures what might be called the temporal acuity of the subject under study. As the BAC level approaches .10 percent, the frequency at which fusion takes place decreases and it may be assumed that impairment of visual acuity has occurred.<sup>15</sup> Two other variables, width of visual field and glare tolerance, do not appear to be influenced to any significant degree by ingestion of even relatively large amounts of alcohol.

To summarize, visual acuity, both dynamic and static, appears to be impaired at those BAC levels approaching .10 percent. In addition, dark adaptation and critical flicker frequency also are impaired at that BAC level. The picture that emerges from the discussion of physiological variables is one which suggests that the nighttime driver who has been drinking heavily is seriously handicapped. In addition, it seems that loss of acuity and reduction in ability to adapt to darkness represent serious losses when the extremely complex visual problems encountered by a nighttime condition are considered. These perceptual losses combined with attentional and emotional changes brought on by alcohol involvement in the reticular activating system present serious problems to the legally drunk nighttime driver. Conversely, while moderate drinkers -- around .05 percent BAC -- may suffer emotional and attentional changes, alcohol involvement at this level does not seem to seriously affect the visual perceptual capabilities of the nighttime driver.

In light of this, it is interesting that in the Grand Rapids Study<sup>16</sup>

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<sup>14</sup>E. M. Jellinek and R. A. McFarland, "Analysis of Psychological Experiments on the Effects of Alcohol," Quarterly Journal of Studies on Alcohol, 1 (1940), pp. 272-371.

<sup>15</sup>M. W. Perrine, op. cit.

<sup>16</sup>R. F. Borkenstein, et al., The Role of the Drinking Driver in Traffic Accidents, (Bloomington, Indiana: Department of Police Administration, Indiana University, Feb. 1964).

moderate drinkers (.05 percent BAC) are underrepresented in nighttime accidents. In contrast, heavy drinkers (.10 percent BAC or more) are overrepresented in nighttime accidents. Based on the physiological evidence, the higher than expected accident rate of heavy drinkers represents their inability to solve complex perceptual problems with a sensory apparatus less efficient than usual.



### III. BEHAVIORAL STUDIES IN A LABORATORY OR CONTROLLED ENVIRONMENT

The second class of research reviewed is that group of studies looking at the effects of alcohol ingestion on the behavior of the individual as a whole instead of functioning neural systems. This class of research treats alcohol as an independent variable which is under the control of the experimenter. In this research, the investigator assigns or determines the amount of alcohol to be taken by the drinker. In some cases, subjects are randomly assigned to groups and the amount of alcohol is randomly determined. In other cases, all people serving in the experiment serve at all levels of alcohol consumption. For example, if there are three different amounts to be drunk -- say, none, four ounces or six ounces of whiskey -- measurements would be taken before the subjects drink anything and again after they drink four ounces. After the effects of the alcohol wear off, the subjects would be tested after drinking six ounces of whiskey.

There are many advantages and few disadvantages to this type of research. The major advantage, and at the same time a disadvantage, is that by random assignment to level of alcohol consumed, the effects of other variables which are presumed to accompany alcohol consumption in the natural state are also randomly assigned. Suppose a certain type of personality (Type A) tends to drink a lot. A comparison of drinkers and non-drinkers (who select themselves) would then involve a comparison of two different personality types. That is, any difference found between the two groups might be due to drinkers versus other types, or a combination of the two types. Laboratory studies effectively eliminate the possibility that a variable tied to or correlated with the variable the investigator is manipulating is actually related to the observed differences in behavior. Differences which are found between two groups may then be attributed to the effects of the manipulated variable and to no other. Therefore the laboratory study can be a powerful tool for research. At the same time, because of ethical and moral considerations, conditions which are of optimal interest cannot be produced in the laboratory. That is, the effects of alcohol on traffic safety can only be inferred from laboratory studies. With the possibility of correlated or confounded variables occurring in field studies, obvious interpretations may not be correct due to more subtle variables, such as personality differences, possibly being masked by a more striking

variable, such as alcohol consumption.

Two general types of study are considered. The first is one which is actually conducted in a laboratory setting while the second involves use of a motor vehicle on some type of course. In both cases, subjects are either randomly assigned to groups or serve in several conditions to reduce the effects of individual differences.

Since reaction time is obviously a most important variable in the proper control of a motor vehicle, it has been extensively studied in the laboratory. In one study, Robinson and Peebles studied reaction time as a function of the amount of alcohol ingested (0 percent, .05 percent, and .10 percent BAC), task difficulty and compatibility of the stimulus-response pairing.<sup>17</sup> A row of eight lights was arranged in front of a row of either two (easy task) or four (difficult task) buttons. The subject's task was to push the button when the lights in front of the button (compatible task) or on the opposite side (incompatible task) came on. Several days practice were given and then the alcohol variable was introduced. At moderate alcohol levels (.05 percent BAC) increased reaction times were found only in the difficult four-button tasks; at high alcohol levels (.10 percent BAC) all tasks showed an increase in reaction time. The greatest increase in reaction time occurred in the difficult-incompatible task under high levels of alcohol, with the increase being greater than would be expected from knowledge of the effects of any variable alone. Reaction time performance was considerably degraded under conditions which meet the legal definition of intoxication.

Not all reaction time studies have found an impairment in performance. Some have found an increase in performance<sup>18</sup> while others have found no change.<sup>19</sup> However, the motivational effects of alcohol ingestion are complex

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<sup>17</sup>G. H. Robinson and W. J. Peebles, "Interactions Between Alcohol, Task Difficulty, and Compatibility in a Choice-Reaction Task," Perceptual and Motor Skills, 38 (1974), pp. 459-466.

<sup>18</sup>M. Vogel, "Low Blood Alcohol Concentrations and Psychological Adjustment as Factors in Psychomotor Performance," Quarterly Journal of Studies on Alcohol, 19 (1958), pp. 573-589.

<sup>19</sup>G. A. Zirkle, et al., "Effects of Chlorpromazine and Alcohol on Coordination and Judgment," Journal of the American Medical Association, 171, No. 11 (1959), pp. 168-172.

and care must be taken to control or eliminate these effects which can interact with other variables to bring about an increase or a decrease in performance.

There has been some interest in attempting to identify what portion of the reaction cycle is influenced by alcohol ingestion. Tharp argued that the task of reading a stop sign aloud involves among other things translating the letters into a verbal code and selecting the appropriate motor speech pattern and then saying the word.<sup>20</sup> In contrast, shadowing -- saying a word after hearing it -- would require only the latter two components of the reading task. Hence, the effects of alcohol consumption upon the time it takes to translate the letters of a word into a verbal code can be determined by looking at the differences between the alcohol versus no alcohol conditions in a shadowing task and that same difference in a word reading task. This subtraction technique was first introduced by Donders in the very late nineteenth century and assumes that such processes as described above are relatively independent. Although such an assumption seems questionable at first glance, it has proven to be an excellent way to form and direct research and it remains effective today.

In the Tharp research,<sup>21</sup> subjects were given enough alcohol to bring the BAC level to approximately .10 percent. In different sessions each subject served in a reading task -- to see the word and then repeat it. Both of these conditions were given under 0 percent BAC as well as .10 percent BAC. In this well-controlled study, each subject was presented the conditions in a different sequence and given five practice items at the beginning of each session, thus effectively eliminating practice effects as a source of error variability. The results of the study were clear cut -- alcohol influenced the reading task but not the shadowing task. That is, there was no difference in reaction time of the shadowing task between the 0 percent and .10 percent BAC conditions. In contrast, the reaction time of the reading task under the .10 percent BAC level was increased considerably over the control condition. If the assumptions are correct, the time it takes to translate from a visual to a verbal code is increased by alcohol consumption while the other components of reading are relatively uninfluenced by the consumption of alcohol.

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<sup>20</sup>V. K. Tharp, Jr., "Alcohol and Driving Performance: An Information Processing Analysis," Alcohol Technical Reports, 4, No. 2 (1975), pp. 12-18.

<sup>21</sup>Ibid.

The relevance of this experiment to driving while intoxicated is as follows: drivers after drinking will have slower reaction times when translating signs from a visual to a verbal code. While practice will tend to mitigate the effects of this increase in translation time, e.g., after a thousand exposures a stop sign certainly will elicit a stop, drinking will still retard the reaction time of both inexperienced drivers and experienced drivers in an unfamiliar driving environment.

Another type of laboratory experiment seeks to evaluate changes in cognitive functioning which occur under the influence of alcohol. If, for example, short term memory, judgment and the like are impaired by alcohol consumption this would have possibly severe consequences for the drinking driver. An example of this type of research is found in a study by Fergenson and Johnson, who investigated the effect of 0 percent, .04 percent, and .08 percent BAC upon information processing, short term memory, and risk taking.<sup>22</sup>

In the information processing experiment, both simple reaction time, consisting of responding to a single light, and a complex three-choice reaction-time paradigm were used. The latter involved using three buttons to be pressed when any one of three lights came on. In general, the difference between simple and complex choice reaction times decreased under the .04 percent BAC level and increased at the .08 percent BAC level -- representing that will-o-the-wisp phenomenon of improved performance at low BAC levels. In this case, the subjects may have traded speed for accuracy, thus decreasing choice reaction times under .04 percent BAC level. This interpretation seems reasonable since both the risk taking and short-term memory portions of the experiment used the same subjects but did not show the biphasic change from low to high levels of alcohol consumption. Instead, short-term memory decreased as alcohol ingestion increased. Similarly, risk taking, as measured by the number of trials occurring before a subject is willing to guess which number in a string of digits is more frequent, increased as BAC level increased; the mean number of digits given before guessing decreased and the difference between the 0 percent and .04 percent levels was almost exactly the same as the difference between the .04 percent and .08 percent BAC levels.

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<sup>22</sup> P. E. Fergenson and J. M. Johnson, The Effects of Low and Moderate Levels of Alcohol Intake on Three Cognitive Parameters Related to Automobile Driving, Pre-Publication Copy (Hoboken, New Jersey: Stevens Institute of Technology).

A different class of laboratory experiment approximates the conditions encountered by drivers of motor vehicles by using a simulated driving test. The assumption, which can be readily verified, is that a simulated driving situation is much like the conditions which are encountered in the usual driving situation. The driving simulator has the twin advantages of possible maintenance of close control over manipulated variables and yet is very close to a "real life" situation.

In one work, Martin<sup>23</sup> studied steering wheel reversal rate, accelerator reversal and brake application with all subjects serving in a driving simulator equipped like an automatic transmission car. The young adult male subjects were given half an hour of practice some time before the start of the experiment and all subjects were tested under approximate BAC levels of 0 percent, .05 percent, and .10 percent. The task was basically a tracking task -- stay on the road pictured in the motion picture. Presentation of conditions was counterbalanced. Of the several dependent variables which were measured, alcohol had the greatest influence upon steering wheel reversals. Two types of reversals were measured: micro-reversals which were movements characteristic of fine steering adjustments and macro-reversals which were movements characteristic of gross steering adjustments such as turning corners. Macro-reversals did not differ under the 0 percent and .05 percent BAC conditions. However, macro-reversals increased about 15 percent under the .10 percent BAC conditions. On the other hand, the 0 percent and .10 percent BAC conditions did not differ with respect to micro-reversals. It is of interest that under the .05 percent BAC condition, micro-reversals decreased about 15 percent. Thus, the picture of the .05 percent BAC driver which emerges is of a driver who restricts his fine adjustments while leaving the gross unchanged. Alternately, the .10 percent BAC driver tends to increase his gross adjustments while leaving the fine adjustments unchanged. This latter pattern may reflect greater concentration on the task by the legally drunk driver with large numbers of gross adjustments. Similarly, the pattern of reduced micro-adjustments found in the .05 percent BAC conditions may reflect an effort on the part of the subject not to overcorrect his steering behavior.

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<sup>23</sup> G. L. Martin, "The Effects of Small Doses of Alcohol on a Simulated Driving Task," Journal of Safety Research, 3, No. 1 (1971), pp. 21-27.

Buikhuisen and Jongman studied the visual search patterns of a group of sober observers and a group of .08 percent BAC observers viewing a moving picture that simulated scenes that would appear to a driver of a car.<sup>24</sup> The task was to observe the film and behave as if the subject were the driver of the car. There were 86 traffic incidents in the film and the sober observers noted more of these than did the drinkers. In addition, subjects who had a BAC level of .08 percent missed incidents away from the center of the screen more often than did the sober subjects.

An experiment using a simulated driving task measured eye fixation and user control errors under either sober or .10 percent BAC conditions.<sup>25</sup> Although steering, acceleration, deceleration, and braking errors all increased from the sober to the .07 percent condition, statistical analysis failed to yield any significant differences. Alcohol consumption was related to a decrease in eye movement frequency. Also, large eye movements which swept the visual field were suppressed and the alcohol impaired drivers fixated on the center of their visual field -- the "tunnel vision effect." That is, the intoxicated subjects suffered from tunnel vision while the sober subjects were able to view the entire screen. This is in agreement with Belt who suggested that ingestion of alcohol narrows the visual field as, illustrated by the concentration of fixations in the center of the visual field.<sup>26</sup>

These studies represent a few of the laboratory studies relating alcoholic consumption to behavior patterns assumed to be important in driving a motor vehicle. In each case reported here, and in the vast majority of reported studies, alcoholic consumption is followed by impaired performance. To the

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<sup>24</sup>W. Buikhuisen and R. W. Jongman, "Traffic Perception Under the Influence of Alcohol," Quarterly Journal of Studies on Alcohol, 33 (1972), pp. 800-806.

<sup>25</sup>S. Schroeder, J. Ewing and J. Allen, "Combined Effects of Alcohol with Methoprylene and Chlordiazepoxide on Driver Eye Movements and Errors," Journal of Safety Research, 6 (1974), pp. 89-93.

<sup>26</sup>B. Belt, Driver Eye Movement as a Function of Low Alcohol Concentrations (Columbus, Ohio: Engineering Experimental Station, Ohio State University, 1969).

extent that the behaviors studied are employed in driving a car or other motor vehicle, it is clear that the intoxicated driver is dealing with a complex problem under extremely difficult conditions.

The second type of controlled studies which will be reported involved actual driving over a course by a subject. There have been a large number of studies which have used this method and a representative sample of recent research will be reported. It is interesting that as the research more closely approximates "real life" situations, the quality of the research in terms of attention paid by the researchers to the design and analysis of their experiments generally deteriorates. As Huntley has indicated, "alcohol and driving research has ranged broadly in terms of technical sophistication and adequacy of experimental design."<sup>27</sup> In all areas of research, there are some studies which are well controlled and executed, and some studies which are bad. In this particular area, the percentage of good studies is less than in those previously discussed.

An additional complicating factor in this type of research is the type of data collected. If a subject under a relatively high BAC is told (either by instructions or by the way the experiment is conducted) that driving errors are the most important aspect of the experiment and should be avoided, then it is quite likely that the subject will "trade off" one aspect of driving such as speed, for another aspect, such as maintaining accuracy. In experiments where such a trade off can be made, accuracy will tend to be maintained while in other experiments where a trade off cannot be made, accuracy will tend to decrease.

Evidence that this situation does occur was found by Hamilton and Copeman.<sup>28</sup> In that study, subjects were required to divide their attention on a tracking and detection task. Ingestion of alcohol resulted in greater attention being paid to those aspects of performance which had a higher priority. In other words, the subjects, after drinking, attended to what they perceived to be the most important aspects of the task at the expense of the less important aspects of the task. It would seem that in a "real life" situation

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<sup>27</sup>M. S. Huntley, Jr., "Alcohol Influences Upon Closed-Course Driving Performance," Journal of Safety Research, 5, No. 3 (1973), p. 149.

<sup>28</sup>P. Hamilton and A. Copeman, "The Effect of Alcohol and Noise on Components of a Tracking and Monitoring Task," British Journal of Psychology, 61 (1970), pp. 149-156.

drunk drivers would compensate for what they perceive to be impaired ability to drive by paying attention to the high priority aspects of the task -- get home and don't get caught.

One of the earlier, classic studies which used a closed course to test subjects in an actual driving situation was performed by Bjerver and Goldberg.<sup>29</sup> In that study, drivers had to maneuver their vehicles in a series of starting, backing, and parking problems. Each problem had to be completed correctly and the response measure was the total time it took to complete all problems. The BAC levels were approximately .05 percent, and under these conditions total time increased by about 25 percent over a control group of sober drivers.

It can be seen that there are several advantages of this type of research over a simulated driving task. This would include an objective response measure as well as a readily varied course which could be standardized and repeated from experiment to experiment. In addition, the task involves many of the same components which are found in the everyday task of driving. The importance is shown in a study by Edwards, Hahn, and Fleishman, who found relatively little correlation between performance of a simulated driving task and actually driving a car.<sup>30</sup> There are self-evident advantages to the use of a closed course driving situation.

In a study by Huntley and Centybear, the effects of alcohol upon driving behavior in a closed serpentine course approximately six hundred feet in circumference were studied.<sup>31</sup> In this experiment several response measures were employed: fine steering reversals and coarse steering reversals, braking, acceleration changes, total time around the course, speed changes of more than two miles per hour and total time the car was going forward faster than five miles per hour. In contrast to many studies using repeated measures designs,

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<sup>29</sup>K. Bjerver and L. Goldberg, "Effect of Alcohol Ingestion on Driving Ability: Results of Practical Road Tests and Laboratory Experiments," Quarterly Journal of Studies on Alcohol, 11 (1950), pp. 1-30.

<sup>30</sup>D. Edwards, C. Hahn and E. Fleishman, Evaluation of Laboratory Methods for the Study of Driving Behavior: The Relationship Between Simulator and Street Performance (Washington, D. C.: American Institutes for Research, Accident Research Center, 1969).

<sup>31</sup>M. S. Huntley, Jr. and T. Centybear, "Alcohol, Sleep Deprivation, and Driving Speed Effects Upon Control Use During Driving," Human Factors, 16, No. 1 (1974), pp. 19-28.



counterbalancing was employed. Alcohol level was approximately .08 percent BAC. The results indicated that under the BAC level indicated, fine steering reversals increased about 30 percent, coarse steering reversals increased 20 percent, accelerator changes increased 25 percent and speed changes increased 12 percent when compared to sober conditions. In this experiment, the subjects had to maintain either a ten or fifteen mile per hour speed and could not reduce speed to compensate for their impaired driving skill. Accelerator and speed changes were much more frequent at the faster rate, but, in the absence of an interaction with a condition of sobriety, these changes cannot be attributed to the effects of alcohol consumption. One interesting analysis in this paper involved an attempt to assess the effects of alcohol on individual differences, in which some subjects react more severely to alcohol than do others. In this respect, Huntley and Centybear found significant differential reactions to alcohol in both the fine and coarse steering changes. Alcohol ingestion influenced the steering of some subjects more than others and this difference was greater than would be expected by chance. The results of this study indicate that considerable impairment as defined by changes in direction and speed occurs under moderate levels of intoxication.

In a study by Hicks, three alcohol concentrations (sober, .08 percent and .15 percent BAC) were used to study the effects of sign brightness in a nighttime experiment.<sup>32</sup> Each subject drove a car along a two lane road upon which signs of high and low reflectivity had been placed. The car was driven at about 40 miles per hour. Alphabetic (permutations of ABC) and numeric (permutations of 123) signs were used and the driver only had to read the numbered signs. The response measure was the distance from the signs when the sign was read correctly. When an incorrect response was given, the data were thrown out. It was found that with increased alcohol concentration in the blood, the viewing distances decreased. No difference was found between the sober and .08 percent BAC, suggesting the biphasic effects mentioned earlier. Practice effects may have facilitated the performance of both the .08 percent and .15 percent groups. However, the deleterious effects of alcohol were sufficient to reduce the viewing distances of even practiced subjects when

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<sup>32</sup>J. A. Hicks, III, "An Evaluation of the Effect of Sign Brightness on the Sign-Reading Behavior of Alcohol-Impaired Drivers," Human Factors, 18, No. 1 (1976), pp. 45-52.

the BAC level got sufficiently high. In addition, bright signs were seen at a greater distance, even in the .15 percent BAC conditions, suggesting that an increase in sign brightness can to some degree compensate for a high level of alcohol in the bloodstream.

In another field test, Zwahlen found data which were in agreement with those found in the laboratory.<sup>33</sup> More specifically, subjects under the influence of a .10 percent BAC alcohol level were more likely to take a chance of driving a car through a relatively narrow aperture than they were when sober. Although this difference was not significant, it did approach significance in the predicted direction.

The following list summarizes some of the ways the drinking driver is affected:

- (1) judgment is impaired,
- (2) inhibitions and restraints relax,
- (3) reflexes slow,
- (4) vision, particularly side vision, is diminished,
- (5) self-confidence increases,
- (6) less able to distinguish small differences in light and sound,
- (7) loses muscular coordination and timing, and
- (8) less able to give attention required for safe driving.

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<sup>33</sup>H. T. Zwahlen, "The Effect of Alcohol on Driving Skills and Reaction Times," Journal of Occupational Accidents, in press, 1976.

#### IV. EPIDEMIOLOGICAL STUDIES

Turning now from controlled studies, we will look at attempts to assess the effects of alcohol upon traffic safety by measuring these effects in "real life" situations. No matter how realistic controlled studies are, the drunk subject has no real expectation of being arrested, injured or possibly killed while intoxicated. At first glance, it would appear inevitable that these considerations would modify the behavior of the intoxicated individual driving under situations where the possibility of real penalties exist when compared to those in the laboratory in which the worst that could happen would be a poor score. As noted previously, the way people drive in the laboratory may differ from the way they drive on the road. Conversely, the way intoxicated subjects drive in the laboratory or on a closed course might differ considerably from the way they drive on the highway. Hence, there is a feeling that controlled studies are often too artificial to be able to measure a driver's behavior in real traffic. For this and other reasons many studies have investigated what happens on the highway.

How can what happens on the highway be studied? One way might be to look at the number of registered drivers as a function of some variable, say age, and then look at accident rates at each level of that variable. If we were to do so we would conclude, in our example, that drivers under 25 were a more "accident prone" group than were drivers over 65. That is, many more accidents per registered driver are observed in the under 25 group than are found in the over 65 group. But to make this conclusion, we would be making the implicit assumption that drivers over 65 drive the same amount as do those drivers under 25. If drivers over 65 were to drive only half or one-fourth as much as drivers under 25, then a simple comparison of accidents per registered driver would have little meaning and our conclusion would be erroneous. For all we would know, the accident rate for drivers over 65 might be greater than those under 25 when number of accidents per mile driven are considered. Indeed, even if number of accidents per mile indicates that the under 25 group has a higher accident rate than the over 65 group, this conclusion would have to be treated with great care. The reason for this higher rate might be that the patterns of driving differ considerably between the two groups. For example, the 65 year old group might drive only on familiar routes. Alternately, the under 25 group

may seek new routes and drive more often in unfamiliar territory. Under these conditions, it would not be surprising that the under 25 group had a higher accident rate. Neither would it be a proper interpretation of the data to conclude that the under 25 group are poorer or less responsible drivers than the over 65 group simply on the basis of differential accident rates.

The extended example comparing the under 25 and over 65 driving groups was used to illustrate the extreme difficulty in dealing with data collected under naturalistic conditions. Whereas laboratory or controlled studies are not necessarily "real life," "real life" studies often involve variables which are confounded, tied or correlated with other variables. It may be that these variables are the underlying cause of the events observed rather than the variable apparently responsible.

For example, at the beginning of this report it was noted that one estimate of the percentage of highway deaths attributable to alcohol involvement was 80 percent. In a laboratory study, the people who drink alcoholic beverages are determined by random assignment. Under these conditions and in the long run, the subjects in the sober condition have the same characteristics in terms of age, sex, personality, socio-economic level, or any other variable as do those subjects in the conditions requiring consumption of alcohol. However, in the field study, those people who drink and drive may be much different from those who do not drink but do drive. Said another way, the drinkers may not have the same characteristics in terms of age, sex, personality, socio-economic level or any other variable as do the non-drinkers and herein lies the extreme difficulty in interpreting and untangling the interrelated sets of variables which occur in this type of research.

One approach which is potentially useful is to determine so called base rates. Returning to our under-25-over-65 example, instead of referring to the number of registered drivers, the actual drivers on the road could be studied. Once the characteristics of those people who are actually using the roads and highways have been determined, some conclusions can be made about those groups which are overrepresented in traffic accidents and those which are underrepresented.

One such base rate study involved nighttime driving and was conducted in

Washtenaw County, Michigan, by Carlson, et al.<sup>34</sup> This study is also reported in Carlson.<sup>35</sup> In this study, nighttime drivers were selected at random by the research team and waved off the road by a traffic policeman. The drivers were asked to take an alcohol breath test to determine their BAC. The variables in the study included weekday versus weekend, time of night (7-9 p.m., 10-12 p.m. or 1-3 a.m.), area (urban versus rural) and volume of traffic (3,000-9,000 vehicles a day versus more than 9,000 vehicles a day). Sites were surveyed on sixteen nights over a period of four weeks. High volume expressways as well as low volume roads were excluded from the sample, and potential sites were grouped according to traffic volume and then randomly selected.

From ten to twenty drivers were stopped at each site and interviewed by a like-sexed interviewer. Almost 90 percent of the sample agreed to be interviewed and to take a breath test measuring BAC. Since the 10 percent who refused to participate might differ in some significant manner from those who agreed to participate, gross estimates were made of the level of intoxication of each driver who had been stopped. These two groups differed little in apparent level of intoxication and there did not appear to be a selection bias operating.

The data from the survey are presented in Table 1, along with data collected under similar conditions from Mecklenburg County, North Carolina.<sup>36</sup> It can be seen from Table 1 that the results of the two surveys are virtually identical. In both surveys, four percent of the sample met the usual legal definition of intoxication (BAC of .10 percent or greater). An additional six to eight percent were found to be "under the influence" (BAC of .05 percent to .09 percent) while an additional ten percent had BAC's of .02 percent to .05 percent. Included in the 0-.01 percent BAC group was six percent who had a noticeable

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<sup>34</sup> W. L. Carlson, et al., Washtenaw County BAC Roadside Survey Report (Ann Arbor, Michigan: Highway Safety Research Institute, The University of Michigan, 1971).

<sup>35</sup> W. L. Carlson, "Alcohol Usage of the Nighttime Driver," Journal of Safety Research, 4, No. 1 (1972), pp. 12-25.

<sup>36</sup> Research Triangle Institute, Mecklenburg County Drinking/Driving Roadside Interview Survey (Research Triangle Park, North Carolina: Research Triangle Institute, 1971).

TABLE 1. DISTRIBUTION OF DRIVERS BY BAC

GROUP	Drivers Classified by BAC Level											
	0.00-0.01%		0.02-0.04%		0.05-0.09%		0.10-0.14%		≥ 0.15%		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Washtenaw County, Michigan	606	81.2	64	8.6	46	6.2	22	2.9	8	1.1	746*	100
Mecklenburg County, North Carolina	596	77.8	80	10.4	58	7.6	23	3.0	9	1.2	766	100
Combined	1202	79.5	144	9.5	104	6.9	45	3.0	17	1.1	1512	100

Note:  $\chi^2 = 3.1$ , df = 4, a = 0.55; no significant difference in the distributions.

\*One breath sample was not analyzed, due to a power failure, and the results of one test were not recorded.

William L. Carlson, "Alcohol Usage of the Nighttime Driver", Journal of Safety Research, March 1972, Volume 4, Number 1, p. 15.

trace of alcohol in the blood and 75 percent who had no trace of alcohol.

In summary, 75 percent of the sample drivers had not been drinking, and about 10 percent registered .05 percent BAC or higher. It is to this latter group that alcohol related accidents are usually attributed. Two variables manipulated in the Washtenaw study were found to be related to the level of BAC. Approximately 14 percent of the drivers on the medium volume roads (3,000-9,000 vehicles per day) were found to have BAC levels of .05 percent or greater while only eight percent of drivers on the high volume roads were found to have the same level of intoxication. Similarly, 21 percent of the after midnight (1-3 a.m.) drivers were found to have BAC levels of .05 percent or greater as contrasted to five and six percent in the 7-9 p.m. and 10-12 p.m. groups. As might be expected, these two variables interacted so that 27 percent of the late night drivers on the medium volume roads had .05 percent BAC or greater as compared to 15 percent on high volume roads at the same time. These data suggest that the driving behavior of drinking drivers is not at all random. The data suggest that alcohol impaired drivers attempted to reduce the possibilities of arrest or an accident by avoiding high volume roads where the amount of traffic could potentially present problems with which they could not cope. These data suggest that, at least at night, an even greater percentage of the drivers on lower volume roads have potentially dangerous BAC levels.

Although rural drivers and weekend drivers tended to have greater percentages of drinking drivers than urban or weekday drivers (9 versus 12 percent in each case) these differences were not large enough to be statistically reliable. In addition, that group of people who had a few drinks before driving -- .02 percent to .05 percent BAC -- did not differ on any of the variables except that they did show a trend in that a greater percentage of these drinkers were out driving late at night. Although this group of drinkers was found in equal numbers on medium and high volume roads, when these data are broken down as a function of time of night we find that before midnight slightly more drivers (between .02 percent and .05 percent BAC) used the high volume roads (7 percent versus 6.6 percent) while after midnight this was reversed with the more moderate drinkers being found on medium volume roads (14.8 percent versus 11 percent). Hence, the pattern of road use in which the drinking driver avoids as much traffic as possible extends to those drinkers who have had only a few drinks before driving.

Other variables were also found to be related to alcohol involvement. In the Washtenaw County study such factors as age, sex and educational level, etc., were noted at the time the drivers were being interviewed and these background variables were investigated to see if they were related to drinking and driving. Sex was a very strong predictor of alcohol involvement; 12 percent of the males and 4 percent of the females had a BAC level of .05 percent or greater. Nearly 28 percent of the 21-through-25 age group had BAC's of .05 percent or greater. This drops off rapidly both for younger (about 2 percent) and older drivers. In the 31-through-35 age group about 10 percent of the drivers had BAC levels greater than .05 percent. This decrease continues and about 5 percent of the 51-through-55 age group had BAC levels at or above .05 percent. Voas reported similar findings, stating that drivers on the road late at night are more likely to be involved in an alcohol-related crash, both because they are more likely to have been drinking and because they are more likely to be the innocent victims of drinking drivers.<sup>38</sup> Since young drivers are overrepresented in nighttime, weekend driving, the young driver is over involved in alcohol-related crashes.

Marital status also was related to drinking; about 40 percent of the divorced and separated group showed greater than .02 percent BAC while only about 20 percent of the married and single groups showed similar involvement. Even at relatively high levels of intoxication, the same relationship held: 11 percent of divorced and separated, 5 percent of married and 2 percent of single drivers had BAC levels equal to or greater than .10 percent.

This then is a general description of the characteristics of the usage of alcohol by the nighttime driver. It should be noted that analysis of percentages in this type of study can be misleading. For example, although equal numbers of drivers were sampled from the high and medium volume roads, it does not follow that the average of the two percentages of drinking drivers from the two locations represents the overall percentage of drinking drivers on the road. This is obviously not the case since more drivers use the high volume roads, and, hence, the high traffic roads should be weighted more heavily when

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<sup>38</sup> R. B. Voas, Alcohol, Drugs, and Young Drivers (Washington, D. C.: U.S. Department of Transportation, National Highway Traffic Safety Administration, 1974).



estimates of the population characteristics are made. Nevertheless, the study is an important one because it gives us an idea of the characteristics of the people who are using our roads and highways and what their drinking behaviors might be.

A second base rate study approached the problem from a somewhat different point of view. Borkenstein, et al. used crash sites as the basis for data collection<sup>39</sup> whereas Carlson, et al. randomly selected sites based on traffic volume.<sup>40</sup> The Borkenstein, et al. study attempted to determine the characteristics of the drivers who passed by crash sites. Hence, the Carlson, et al. survey is able to generalize to a larger population, nighttime drivers, while the Borkenstein study must restrict its generalizations to the characteristics of drivers in the vicinity of places where motor vehicle accidents occur. That is, to continue the example used in the Washtenaw County study, it may be that most accidents occur in high traffic volume areas. Hence, this type of sampling procedure could conceivably miss most of the drinking drivers since they use low volume roads. The similarities between the two studies may seem to be too great and the distinction between the two sampling procedures may seem to be too small to make the two studies really different from one another. However, the difference in procedures is an important one and it should be kept in mind.

Despite its apparent frequency, the motor vehicle accident and/or traffic fatality is a relatively infrequent event when the total number of miles driven on the highways each year is considered. It was for this reason that the Grand Rapids study, as Borkenstein, et al. is commonly called, was conducted with the sampling procedure used. The data from the Grand Rapids study were collected from July 1, 1962, to June 30, 1963. Data from over 9,000 drivers involved in crashes and data from an additional 8,000 randomly selected crash site drivers serving as controls, were used in the study. (Grand Rapids requires the reporting of all crashes, no matter how small.)

The control subjects were selected in the following manner. About 2,000 crash reports were selected from those reported the previous years. Each

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<sup>39</sup>R. F. Borkenstein, et al., op. cit.

<sup>40</sup>W. L. Carlson, et al., op. cit.

crash report designated the site where it occurred and when it occurred. The research team went to this site at that time (hour and day of the week) and selected four drivers at random. This was repeated until each of the 2,000 sites had been visited, which resulted in a total of 8,000 control drivers. The resulting control group distribution closely resembled that of the experimental group of actual crash-involved drivers.

After the control driver was stopped by a police officer, the driver was interviewed and was asked a wide variety of background questions, as well as questions regarding drinking frequency. A breath test was also given to determine BAC levels in the controls.

Similarly, the research team went to as many collisions and/or crashes as they could to interview drivers in the experimental (or crash) group. After receiving assurances of immunity, the crash drivers were similarly interviewed and a breath test was given to determine the BAC levels in the crash group. Since not all drivers involved in crashes could be interviewed at the time of the crash (several crashes may have occurred at the same time and some of the drivers may have been dead or unconscious), those who were not were interviewed later. Although transient effects, such as BAC, could not be compared, a comparison of background variables did not reveal any difference between the interviewed and non-interviewed groups.

The data from the Grand Rapids study have as yet to be completely analyzed. So many data were collected that individual research workers have been analyzing data and publishing them over the past ten years and much remains to be done.

It should be noted that, although there are a large number of differences in methodologies used in the Washtenaw County nighttime traffic survey and the Grand Rapids study, the results are similar enough to warrant comment. For example, in the 1-3 a.m. group in the Washtenaw study, 21 percent of the drivers had BAC levels equal to .05 percent or higher while the comparable midnight to 3 a.m. group (control group) in the Grand Rapids study contained 17 percent with BAC levels at or above .05 percent. The Washtenaw 10-12 p.m. group had 6.1 percent of the sample with BAC's of .05 percent or higher while in the comparable 9 p.m. to midnight group of the Grand Rapids study 5.1 percent of the sample had similar BAC levels. Other possible comparisons show a similar agreement. Recall that the Grand Rapids survey sampled where accidents

occurred and the Washtenaw County study reported that drinking drivers tended to go where they would not be involved in accidents. Under these conditions, the similarity in BAC levels seems remarkable and is a testimony to the thoroughness with which the two studies were conducted.

One important analysis in the Grand Rapids study shows the relationship between a traffic accident and BAC. As might be expected, relative accident involvement is directly related to BAC level. That is, as BAC level increases, the likelihood of being involved in a crash also increases. However, the relationship is much more complicated than it initially appears to be. Figure 3 shows the relationship between BAC level, two time periods and relative involvement. Relative involvement simply refers to the ratio of the difference between the expected accident rate, derived from the control group, and the actual accident rate. This difference is expressed as a percentage. Thus, a relative involvement score of zero would mean the same accident rate for both crash and control groups and a score of 1.00 would mean that twice as many accidents occurred for some group or other than was expected. Similarly, a negative score indicates that fewer crashes than expected occurred. It can be seen that the groups with .08 percent BAC and greater are overrepresented in accidents. That is, this group is involved in more accidents than would be expected (on the basis of random or chance behavior) from their numbers in the control population. This over representation occurs in the 3-6 p.m. group as well as the midnight to 3 a.m. group. Notice, however, the remarkable difference between these groups when the lower BAC levels are considered. While those drivers who had been drinking in the afternoon are overrepresented in the number of accidents they were involved in, the late night drinkers are actually underrepresented. That is, if time of day is ignored, BAC level and traffic accident involvement are closely related. But when time of day is considered, two differing relationships are found between BAC level and relative involvement in accidents. This interaction between BAC level and time of day appears to be somewhat related to time of night and choice of road in the Washtenaw County survey. That is, both the Washtenaw County and the Grand Rapids studies suggest that late night drinkers take steps to counteract impairment due to alcohol consumption. In the latter study, they are involved in fewer accidents than would be expected, while in the former study one of the mechanisms used to reduce the likelihood of being involved in

FROM: R. Zylman, "The Variability of Collision Involvement at Low Blood Alcohol Concentrations; The Grand Rapids Curve Explained," Blutalkohol, 9, No. 1 (January 1972), p. 27.

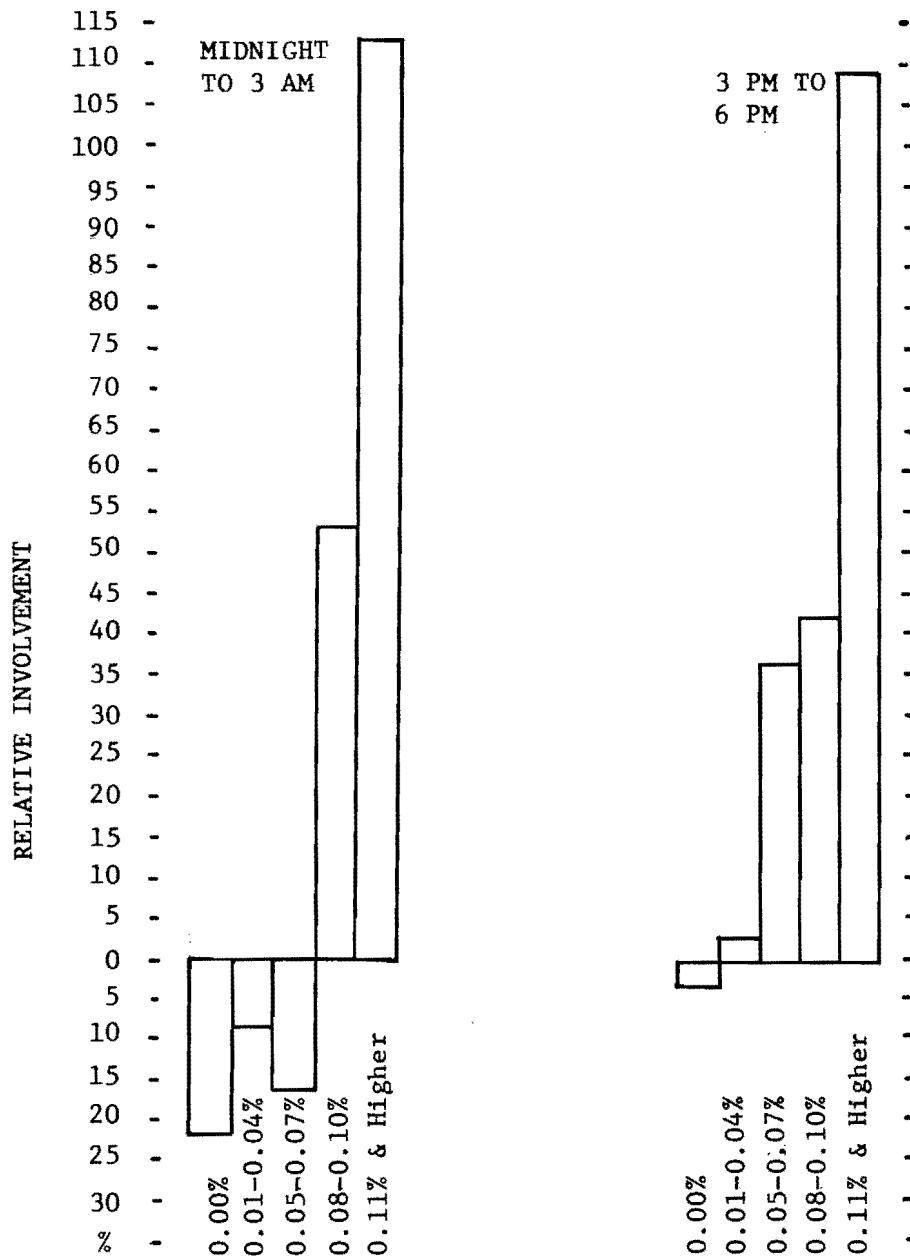


FIGURE 3  
RELATIVE ACCIDENT INVOLVEMENT FOR VARIOUS BAC  
GROUPS OVER TIME OF DAY

an accident is shown -- the increased usage of medium traffic-volume roads. Thus, some distinction must be made between the moderately impaired (up to .08 percent BAC in the Grand Rapids study) and the considerably impaired (above .08 percent BAC) driver. Those drivers with less than .08 percent BAC recognize their level of impairment and take steps to avoid the consequences of such impairment.

In summary, the drinking driver can compensate only to the degree that sparse traffic will preclude the need for quick judgment and reaction. As traffic density increases, the need for those faculties also increases; hence, in heavy traffic (as would be the case in the daytime portion of Figure 3), drivers who have any alcohol in their blood are more likely to experience an accident than if they had none.<sup>41</sup>

The less experienced drivers were the very young or the very old; the drivers with low BAC levels tended to be more experienced at driving than those who had not been drinking and a proficient driver could drink a small amount and still do better than the inexperienced driver. This coupled with the driving strategies of the drinker, e.g., to drive when traffic volume is low, increases the likelihood of the drinker's avoiding an accident. Alternately, inexperienced drinkers are not likely to be able to measure the effects of alcohol on their system and hence are less likely to take measures to avoid heavy traffic. All this leads to the rather strange statement that at both low (.01 percent to .04 percent) and at moderate BAC (.05 percent to .07 percent) levels, the chances of being in an accident are reduced when there are more drinkers on the road and increased when there are fewer drinkers on the road.

The type of accident which occurred in the Grand Rapids study appeared to be directly related to the BAC but this also is misleading as the minor "fender-benders" tended to occur during the 6 a.m. to 6 p.m. period while fatal crashes tended to occur at night. Two thirds of the crashes in the Grand Rapids study caused less than \$300 damage while a fatal crash usually would totally demolish the car.

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<sup>41</sup>R. Zylman, "Accidents, Alcohol and Single Cause Explanations: Lessons from the Grand Rapids Study," Quarterly Journal of Studies on Alcohol, Supplement No. 4 (1968), pp. 212-233.

The results of the Grand Rapids study show that the relationship between drinking and driving is a complex one. Under these conditions, demonstrations of the relationship between a single independent variable -- BAC -- and probability of an accident can often mask a more complex interaction between several variables. In this case, BAC level, time of day and driver experience all interact and the effect of any one of these variables must be examined in the context of the others. Unless this is done, it is likely that erroneous or misleading conclusions will be drawn.

However, several major points about the complex nature of the relationship of alcohol to accidents are worth keeping in mind. In general, the probability of a crash increases as blood alcohol concentration increases. The research reported indicates that temporary physiological changes caused by alcohol impair attention span, alertness, visual acuity and reaction times. Alcohol consumption also has been shown to increase risk-taking behavior. The inexperienced driver as well as the driver in unfamiliar territory is particularly vulnerable to accidents when under the influence of alcohol.

There seems to be no doubt that alcohol consumption seriously affects safe driving practices, despite drinking drivers' attempts to compensate for their impairment. The effect of alcohol on traffic safety has unfortunate consequences for the drinking driver and also for the non-drinkers on the roads and highways.

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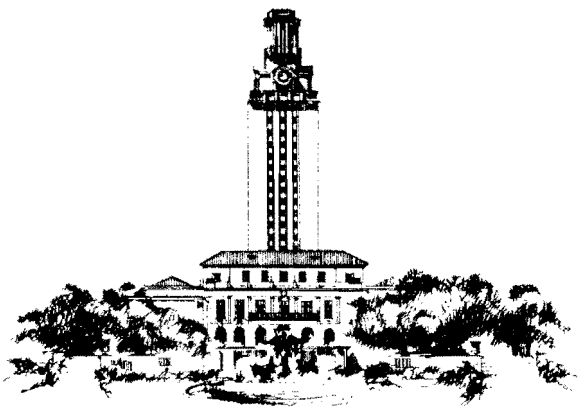
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